

Report No. UT-03.26

***EVALUATE
EFFECTIVENESS OF HIGH
OCCUPANCY VEHICLE
(HOV) LANES***

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16. Abstract In May of 2001, 16 miles of High-Occupancy Vehicle (HOV) lane opened on the re-constructed I-15. the HOV lanes operate between 600 North and 10600 South in the Salt Lake Valley, a single HOV lane in each direction. The HOV lanes are successful in their operation based on this reports assessment. while successful and anticipated to be increasingly valuable as the congestion in the Salt Lake Valley increases, there are some recommendations to improve the HOV lanes' performance discussed in the findings.					
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LIST OF ACRONYMS

ATMS	Advanced Traffic Management System
AVO	Average Vehicle Occupancy
FHWA	Federal Highway Administration
GP	General Purpose lanes
HOV	High Occupancy Vehicle
ITS	Intelligent Transportation System
MOE	Measure of Effectiveness
SOV	Single Occupancy Vehicle
TMS	Traffic Monitoring System
TOC	Traffic Operations Center
UDOT	Utah Department of Transportation
USDOT	United States Department of Transportation
VPH	Vehicles per Hour
VPLH	Vehicles per Lane per Hour
WFRC	Wasatch Front Regional Council

EXECUTIVE SUMMARY

In May of 2001, 16 miles of High-Occupancy Vehicle (HOV) lane opened on the re-constructed I-15. The HOV lanes operate between 600 North and 10600 South in the Salt Lake Valley, a single HOV lane in each direction is separated from the four general-purpose freeway lanes by striping only allowing entrance and exit of the lane along the entire corridor. The HOV lanes operate 24-hours and allow 2+ occupancy vehicles, motorcycles and transit vehicles. The only HOV specific access to an arterial is located at 400 South and allows HOV only direct access to the I-15 southbound on-ramp and I-15 northbound off-ramp. This reports on the two-year study evaluating the HOV lane performance. The analysis assesses the freeway operations before the HOV lanes opened with continued assessment throughout the first year of operation. Automatic data from traffic monitoring stations and manual data from roadside and travel time surveys provided the information to evaluate the HOV lane performance during the first year of operations.

The findings indicate that during the afternoon peak period, the HOV lane moves the same number of people as each general-purpose (GP) lane with only 44% of the vehicles. The HOV lane moves less people than its GP lane counterparts throughout the rest of the day, during times of little or no congestion. HOV lanes show travel-time savings for HOV users. According to measures of travel time between 400S and 10600S, relative to the adjacent GP lanes, the HOV lanes provide a 30 percent travel-time savings during the afternoon peak period, and a 13 percent travel-time savings during the morning peak time. Furthermore, unlike the higher variation of travel times on GP lanes, HOV lanes provide a more consistent and predictable travel time, due to stable travel speeds from the less congestion and incidents. The HOV lanes violation rates range from 5 percent to 13 percent along the I-15 corridor, which is slightly higher than the 5-10% expected by national averages. At the 400 South HOV on / off ramp the violation rates increase to 20 percent. Recurring surveys during the initial year of HOV operations shows that violation rates

initially reduced after the HOV lane opening and have since stabilized. Average vehicle occupancy on I-215 and non-HOV portions of I-15 have remained the same before and since the HOV lane opening. Vehicle occupancy on the I-15 corridors with HOV lanes experienced a 17 percent increase, from 1.1 persons per vehicle to 1.3. Therefore, implementation of the HOV lanes has induced carpooling, which indicates that HOV lanes have received public support. The HOV lanes are successful in their operation based on this assessment. While successful and anticipated to be increasingly valuable as the congestion in the Salt Lake Valley increases, there are some recommendations to improve the HOV lanes' performance discussed in the findings.

CHAPTER 1. INTRODUCTION

High-Occupancy -Vehicle (HOV) lanes have been implemented throughout North America as a way to maximize the person-carrying capacity of a facility by offering travel-time savings as well as reliable and predictable travel times. HOV lanes in several states, including New Jersey, California, and Virginia, have recently come under fire for what is termed the “empty lane syndrome,” or perception of underutilization. Two facilities in New Jersey, I-80 and I-287, were decommissioned in November 1998 under political pressure. In these particular cases the facilities lacked some of the fundamental design and operational characteristics common to successful HOV lanes and local users deemed the lanes wasteful (1,2,3).

In Salt Lake City, May 2001, UDOT completed the Interstate 15’s (I-15) reconstruction. With that reconstruction was incorporated 16 miles of High-Occupancy -Vehicle (HOV) lanes. The reconstruction increased I-15 from three general-purpose lanes in each direction to four general-purpose lanes and an HOV lane per direction. This report documents the findings of the two-year process of assessing the HOV operation and usage. It includes an assessment of the freeways prior to the HOV lane opening and the first year of HOV operations. Volume, speeds, vehicle occupancy and violation rates for the HOV and General purpose lanes are compared to one-another and to the before HOV lanes / with HOV lane conditions.

Figure 1-1 shows the HOV lanes are located on I-15 from 600 North to 10600 South in the Salt Lake Valley. A painted solid white line is all that separates the single HOV lane from the four General Purpose (GP) Lanes per direction along the length of the corridor. This allows ingress and egress to the facility along the entire corridor. The open access of striping allows for maximum flexibility for users however, this open access is also when congested GP lanes use the HOV lane for queue jumping by Single Occupancy Vehicles (SOVs). Besides the open access from adjacent lanes, there is also one location at 400 South, near the CBD of Salt Lake City,

where an exclusive HOV ramp is provided. The HOV ramps provide direct access for northbound exiting vehicles and southbound entering vehicles. In regard to the current operating policies, the HOV lanes are enforced 24 hours a day, seven days a week and reserve usage to vehicles with two or more passengers (carpools, vanpools and buses) and motorcycles. The question of continuous enforcement or only operation during peak hours is one the national as a whole is assessing now.

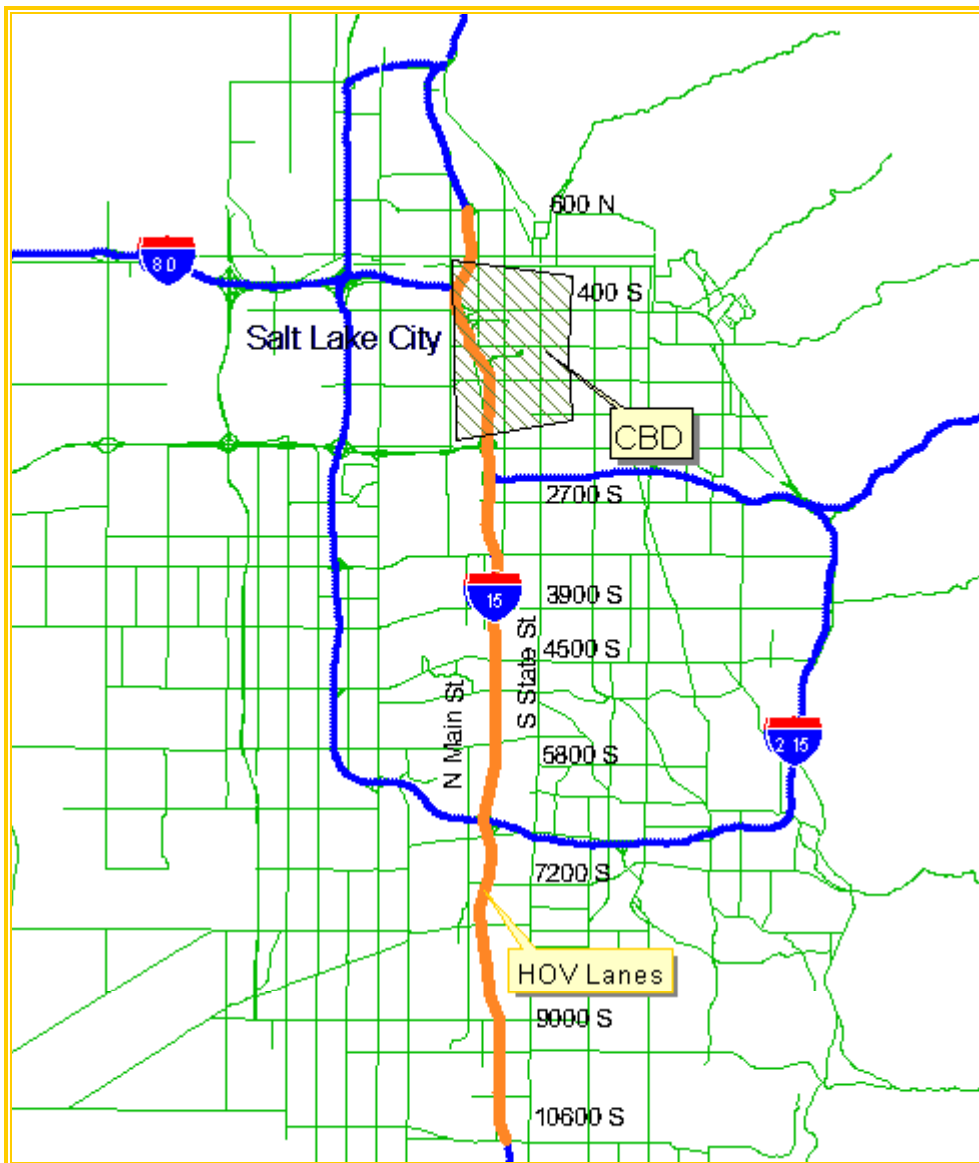


Figure 1.1 HOV Lanes Along I-15 Corridor in Salt Lake Valley

Transportation is the movement of people or goods from where they are to where they are of more value or want to be. Therefore moving vehicles is not an inherent goal of transportation. If more persons can be moved in fewer vehicles, then congestion is lower and the transportation system is more efficient. One of the main objectives of the I-15 HOV lanes, and HOV lanes in general, is to increase the average number of persons per vehicle. Knowing the effectiveness of the I-15 HOV lanes is important for policy-making decisions including: whether to implement HOV lanes on other freeways in the area, determining the minimum passenger level (2 to 3 passengers). Violation rates are an indicator of the public acceptance of the HOV lanes. This is also a measure of risk versus benefit of violating. The impacts on alternate routes and their performance is also assessed. While this report documents the assessment of the first year of HOV operation, ongoing assessment and monitoring is the key to continued acceptance and successful operation of the HOV lanes. This continuous monitoring allows decisions to be made about the HOV operations and benefits as the congestion of the freeway increases in the future. The success and benefit should continue to increase as the congestion in the Salt Lake Valley increases.

The Utah Department of Transportation (UDOT), in conjunction with the University of Utah and Mountain Plains Consortium, a federally supported ITS program, conducted a two-year study. The project purpose is to determine the HOV lane effectiveness. The research objectives are:

1. Evaluate the impact of HOV lanes on I-15 and alternate routes.
2. Measure the effectiveness by comparing before and after opening information with the HOV lanes.
3. Recommend any changes to the existing HOV operations policies or procedures.
4. Review and recommend educational programs for improving acceptance and compliance.

It is important to assess the HOV lane's performance since the recent increase in capacity on I-15 may actually promote a decrease in occupancy by increasing available travel opportunities. In order to meet the research objectives mentioned above and determine if the HOV lane is successful, the following tasks were completed:

1. Review of success and failures in other metropolitan areas
2. Determine Measure of Effectiveness (MOEs)
3. Collect field data with and without the HOV lanes operating
4. Comparison of effectiveness and acceptance
5. Measure the benefits being provided from the HOV lanes

CHAPTER 2. LITERATURE REVIEW

2.1 Review of Other Evaluations

Many other transportation systems have incorporated and evaluated HOV and components similar to the Salt Lake system. Much can be learned from their experiences, evaluation methods, and findings. This section is organized into individual discussions of several related HOV evaluations, followed by a general discussion of each evaluation by component.

Houston System

The I-10W Katy Transitway is a 11 mile radial corridor originally built as a transit expressway and after it opened, HOV 2+ vehicles were allowed in addition to transit vehicles. Presently, the corridor is HOV 3+ during the peak hours and HOV 2+ at regular hours. About 45% of the people on the Katy use buses. The success of the Katy has helped pave the way for a growing network of HOV lanes in Houston adding to 74 miles (4).

Oregon Evaluation

The Oregon Department of Transportation conducted an evaluation of I-5 before and after the introduction of a HOV lane (5). Four follow-up evaluations have been conducted in all and the results from the last evaluation show:

- HOV lane drivers are on average, saving eight to ten minutes on their commute over the entire length of the corridor.
- The number of persons using the HOV lane is greater than the number of persons using a general-purpose lane. The HOV lane carries approximately 2,600 people per hour and a typical general-purpose lane in the same area carries about 1,700 people per hour.
- Occupancy compliance continues to be about 92 percent. The percentage is average compared to HOV lanes nationwide.

New Jersey Failure

New Jersey recently closed two HOV lane facilities, I-80 and I-287, and opened to all GP vehicles. The HOV lane on I-287 was used very little with under 400 vehicles per lane-hour (vplh). This flow was not nearly high enough to alleviate the high congestion problem on this corridor. The I-80 HOV lane was, however, used heavily with over 1000 vplh. There was political opposition that spilled over from I-287 to close I-80. Neither one of these HOV facilities carried much transit service nor did the decision makers did not prepare the public for the opening of the lanes and benefits to the systems as a whole and therefore there lacked an insufficient HOV market (4).

Virginia Success

In northern Virginia I-66 extends west from downtown Washington, D.C. The HOV lane on this corridor was originally a HOV 3+ lane but was changed to HOV 2+. This relaxation of restrictions produced a 60% percent increase in ridership (to 1700 vplh) (4).

California Evaluation

Caltrans operate 1,061 lane-miles of HOV lanes with 162 lane-miles under construction and 1114 lane-miles through 2030. On average, California's HOV lanes carry 2,518 persons per hour during peak hours—substantially more people than a congested mixed-flow lane and roughly the same number of people as a typical mixed-flow lane operating at maximum capacity. In terms of vehicles carried, however, California's HOV lanes are operating at only two-thirds of their capacity. There has been some political discussion that HOV lanes slow alternative fuel vehicles to utilize the HOV lanes as a way to increase the alternative vehicle attractiveness.

Transportation engineers are slow to accept this idea as they are trying to focus on the purpose, which is people movement. There are some locations where dual occupancy is being

implemented. This includes 2+ occupancy during off-peak times and 3+ during peak-times.

Some bridges in the San Francisco Bay area eliminate tolls for HOV vehicles during peak times.

Regional data indicate that HOV lanes do induce people to carpool, but the statewide impact on carpooling is unknown due to lack of data. The exact impact of HOV lanes on air quality is also unknown (3,6).

Seattle HOV Evaluation

In the Seattle, Washington – Pudget Sound area, there are 205 lane-miles of HOV lanes with 330 lane-miles planned by 2010 and 500 more lane-miles by 2030. More than 100 of these lane-miles are on arterial. According to the Washington State Department of Transportation (WSDOT) HOV study (7, 8), congestion occurs for nearly 14 hours per day. HOV lanes average between 700 and 900 vehicles per hour during the midday periods with HOV lanes carrying as many people as the general-purpose lanes. In a public perception survey, 95% of the HOV users thought HOV lanes were a “good idea” which is not but surprising but 72% of the single occupancy vehicles (SOVs) agreed. The top five options to improve HOV lane usage were determined to be:

1. Better Enforcement
2. Inside access ramps
3. HOV lanes to inside lanes
4. Employer subsidies
5. Increased bus service

The Washington State Patrol (WSP) wrote 3,500 warnings and 9,000 tickets were issued during 2000. This represented a 49% increase in violation citations. The increased enforcement was coupled with the new HERO program. HERO is a way for motorist to self monitor the HOV lanes by reporting violators via web or phone. Those reported violating the HOV lanes are sent educational material on HOV lanes for their first reporting. A second reporting and WSDOT sends a personalized letter emphasizing the proper use of the HOV system. A third reported offense and the WSP sends a personalized letter noting the date, time and location of the reported

violation. The HERO program received 43,879 reports of violation in 2000, a 6% increase from 1999. Less than 6% of those reported were second time offenders and less than 1% were three or more time offenders. The program is credited with reducing repeat HOV violators.

Performance Summary

Nationwide, there are 22 cities with HOV lane and more than 2000 lane-mile, half in California alone. Approximately 52% of the HOV lanes are enforced 24 hour a day, 7-days a week. Approximately 86% of the HOV lanes operate as 2+ facilities with the remainder requiring 3+ ridership. More than 80% of the HOV users have 2 riders in the vehicle. When HOV user requirement increase to 3+, 80% of an HOV lane use is reverted back into the general-purpose lanes. HOV lane violation is on average 10-15% nationally. The target for HOV lanes is to increase vehicle occupancy and reduce travel time for both private vehicles as well as the transit service. MOEs typically include volume, vehicle occupancy, speeds/travel times, violations and public attitudes. Continued monitoring is a key to the success of the programs across the nation to inform the public of the ongoing benefits of the system. Southern California has 40 sample locations monitoring 400 of its 1061 lane-miles.

2.2 Review of other agencies educational programs

Marketing HOV Lane in Long Island

A HOV lane on the Long Island Expressway underwent an extensive marketing effort. The HOV lane opened in 1994 but the marketing of the lane began much earlier. The marketing program had two major objectives: 1) promote the HOV project to stakeholders as a highway improvement project in order to get support for the project, 2) build a constituency among potential HOV lane travelers to an acceptable level of usage. The basic strategy to market the HOV lane to stakeholders had three parts. The first part was to provide factual information to stakeholders

about the system and other HOV lanes around the country. The second part was to develop the planning process outside of the traditional departments and in cooperation and coordination with other agencies. The third part of the marketing campaign was to bring together a diverse collection of private and public interests early in the project in order to encourage support for the HOV concept (9).

Gaining Public Acceptance in Tennessee

The Tennessee Department of Transportation (TDOT) implemented an HOV lane in 1993. The lane has achieved a high level of support due mostly to a collective marketing effort from TDOT, the Regional Transportation Authority, and other state and local jurisdictions. Free media and paid advertising were used in the marketing campaign. Direct mail was sent to 38,000 residents and newsletters were provided to public policy makers. The paid advertising included airtime on television and advertisements in the newspapers. In addition, outdoor billboards, bus bench boards, and signs on buses were used. The total cost of the campaign was approximately \$100,000 (10).

Marketing in New Jersey

While the New Jersey HOV lane failure was a transportation setback, there is still a successful HOV facility in the exclusive bus lane serving the Lincoln Tunnel. With knowledge gained from these two very different situations, New Jersey implemented a \$2.5 million marketing campaign to promote a new HOV lane on I-80 in Morris County. The marketing campaign had six goals:

- Heighten public awareness of the HOV mission
- Build constituencies and partnerships with employers, and elected officials, and elected officials at the local, county, and state level.

- Increase public confidence.
- Develop accurate expectations.
- Encourage HOV facility use and mode shift.
- Enhance future HOV project planning.

There were a number of marketing strategies used. The first strategy was to create good relations with the print media. Briefings were held with the newspapers and reporters were given status reports throughout the project. The second strategy was to provide information to television and radio. The third strategy was to hold press conferences. Numerous conferences were held at various points in the project. The forth strategy was provide mailings and other distributions. One million people were contacted through direct mailings, fliers in windshields, and notices with license renewals (11).

Marketing Features and Benefits of Carpool Lanes

Donna Carter, Frank Wilson and Associates have experience in marketing carpool lanes. Ms. Carter shared some of her experiences at the 7th International Conference on HOV systems in 1994 (12). According to Carter, HOV lanes are implemented as a part of a major highway reconstruction. Marketing is difficult in this case. Carter says the best method is to present the entire transportation system as a whole and provide information on HOV lanes as part of that system. Carter has found that much research has been conducted looking at motorists' reaction to HOV lanes. It has been found that motorists find the name HOV to be confusing. Research has also found that people think in terms of time and not miles. As a result, HOV benefits should be presented in terms of time. Carter also noted that research has indicated that people overestimate the HOV violation rate. There are some areas where travelers thought that violation rates were as high as 70 percent when in reality the violation rate was under 10 percent. It is important to emphasize in the marketing effort that violators in the HOV lane will be fined. Carter felt that

safety on HOV lanes must also be emphasized. HOV lanes look different to commuters and the perception is that the lanes are not safe. Commuters must be educated on this matter to dispel this perception. In closing, Carter noted that marketing efforts must continue after the HOV lane is opened. Continuous communication is critical to illustrate to the public the benefits of HOV lanes.

CHAPTER 3. METHODOLOGY AND DATA COLLECTION

3.1 Purpose of Evaluation

Evaluations of transportation projects have three main purposes: to compare alternatives, to measure a project's worth, and to determine if a project's goals are being met. Researchers often use evaluation results to select alternatives, which ensure that a project meets intended goals, and identifies areas of improvement. Evaluation results can help with decisions on similar projects.

Federal Highways (13) suggest four reasons to evaluate an ITS system, and place each on a timeline as shown in Figure 3.1.

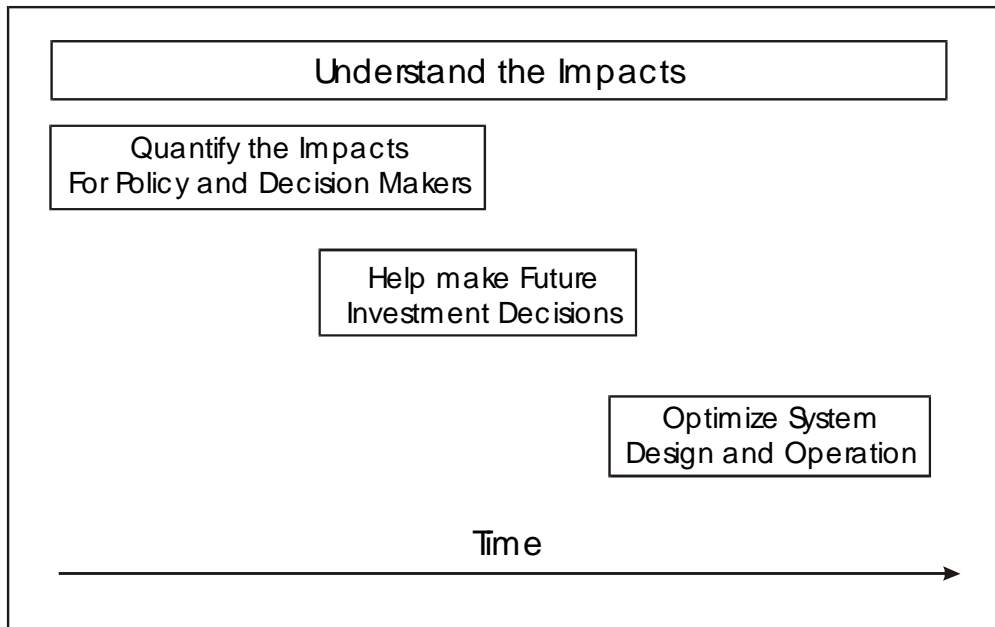


Figure 3.1 Four Reasons to Evaluate ITS System

Adapted from Federal Highways (13)

Federal Highways (13) also hypothesize that evaluations often focus on the first step of quantifying the impacts of a project. Less often, system evaluations are compared to other evaluations to provide a matrix of choices that may help make future investment decisions. ITS systems in particular are only occasionally evaluated for system optimization and operation

refinement purposes. To understand the full impacts of a system, evaluations should be designed for all three purposes.

3.2 Data Collection

The data collection supports the MOE analysis. The MOEs incorporated into the analysis are based on the typical HOV evaluation measures including: Volume, speed, travel time, violation and vehicle occupancy. The freeway TMS sites provided large automated data for volume and speed. Travel time, violations and vehicle occupancy are based manual field surveys. Data collection included time periods before the HOV lanes opened, after they opened in May of 2001, and recurring measures throughout the first year of operation.

3.2.1 Location of Data Collection

To investigate the effectiveness of the HOV system, person and vehicle volumes are analyzed at specific sites along the HOV corridor. The results are then compared with those of GP lanes during AM and PM peak periods in the peak travel direction. The purposes of these measures are to determine whether the HOV lane is enhancing the person-carrying capacity of the system, and to what extent an HOV lane is being utilized. Various MOEs are incorporated to identify the HOV lane performance. For the data collection, the locations and data collected included:

Vehicle Occupancy

- 4 locations along I-15 to provide data representative of the corridor
- 1 location at I-215 East (4500 South)
- 1 location at I-215 West (3100 South)

Travel-times / Volume Counts / Speeds

- I-15 (5 morning and 5 afternoon peaks)

- I-215 East (5 morning and 5 afternoon peaks)
- I-215 West (3 morning and 3 afternoon peaks)
- Traffic Monitoring Stations (TMSs)

Volume Counts / Speeds

- I-15 (3 morning and 3 afternoon peaks)
- I-215 East (3 morning and 3 afternoon peaks)
- I-215 West (3 morning and 3 afternoon peaks)
- Traffic Monitoring Stations (TMSs)

HOV Violation Data

HOV violation data was collected at the 400 South HOV on/off ramp. Vehicle occupancies were collected for traffic entering and exiting I-15 from both directions. It was noted whether or not the vehicles qualified for HOV lane use and the percentage of vehicles in compliance was found.

Data was collected in 15-minute intervals for one and a half hours in the PM peak period on a recurring monthly basis. HOV lane violation data was also collected at representative locations along the I-15 corridor.

CHAPTER 4. HOV LANE UTILIZATION

4.1 GP Lanes vs. HOV Lanes 24-hour Volume Profile

Throughout the Salt Lake Valley, TMSs are located along the freeways system in 800-meter intervals. The TMSs provide, volume, speed and detector occupancy data. Figure 4-1 displays an example data collected at the 5800 South TMS site on I-15. This figure illustrates the 24-hour traffic volume profile on a typical weekday. Multiple TMS sites provided the data for the analysis of speed and volume and HOV usage along the I-15 corridor. The AM and PM traffic peak periods were identified as 6:30 to 8:30 A.M. in the northbound direction and from 4:00 to 6:00 P.M. in the southbound direction. This directional split is consistent with the I-15 HOV corridor connecting the downtown Salt Lake City, which is the dense employment districts, with the southern residential suburbs.

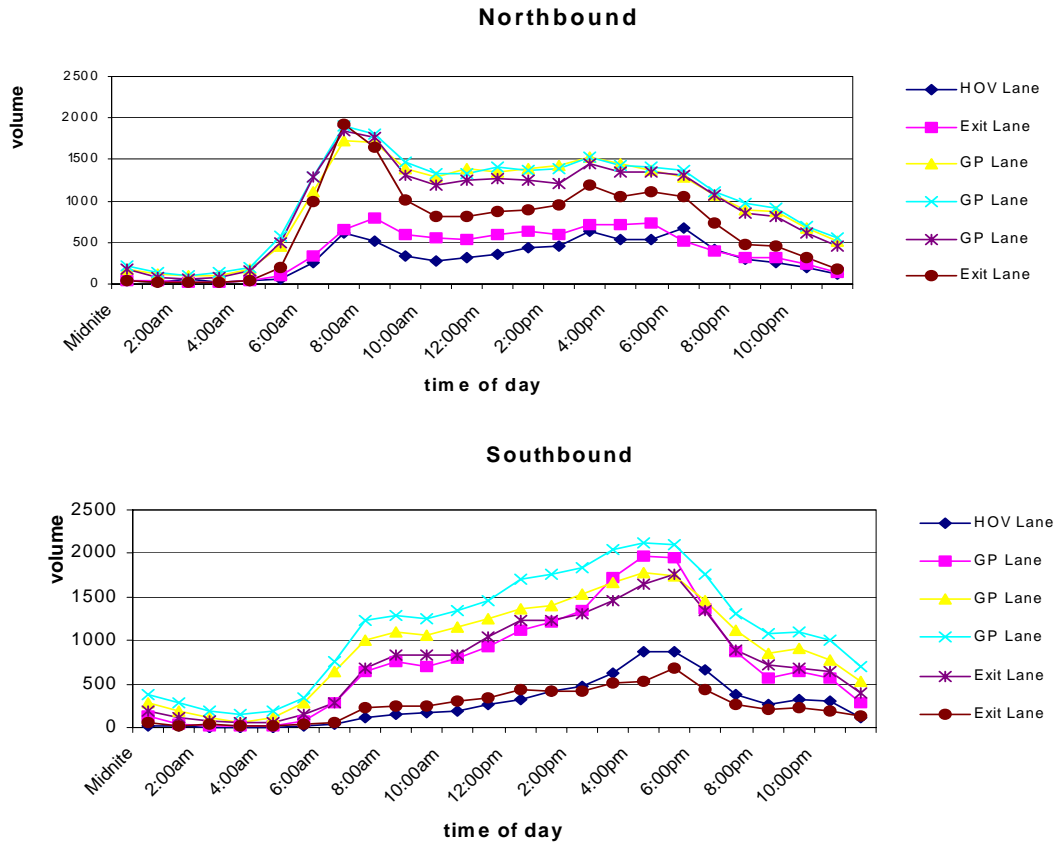


Figure 4.1 24-Hour Traffic Volume Profiles At 5800 South

On a per-lane basis, the HOV lanes carried fewer vehicles in comparison to the GP lanes. During afternoon peak-use times, the traffic volumes in some GP lanes approached 2,200 vplh, the maximum lane's capacity under ideal conditions. Figure 4.1-1 also shows that the utilization of HOV lane is higher from 3:30 to 6:30 P.M. on the I-15 Southbound, in contrast, the HOV lane volumes on the I-15 Northbound stay relatively constant from 7:00 A.M. to 7:00 P.M.

4.2 GP Lanes vs. HOV Lanes Mode Split

Figure 4.2-1 shows the vehicle classification percentages on I-15 at 3900S during the peak periods. The percentage of vans and buses on the HOV lane is higher than the GP lanes. The express buses operated by Utah Transit Authority (UTA) frequently use this HOV facility during peak periods. Buses comprise 2.5% of traffic on the HOV lanes, and only 0.1% of traffic on the

GP lanes. Figure 4.2-1 shows the percentages of people that buses, cars, and vans carry on I-15 at a sample 3900 South location during the peak periods. Buses carried 27.6% of the people on the HOV lanes.

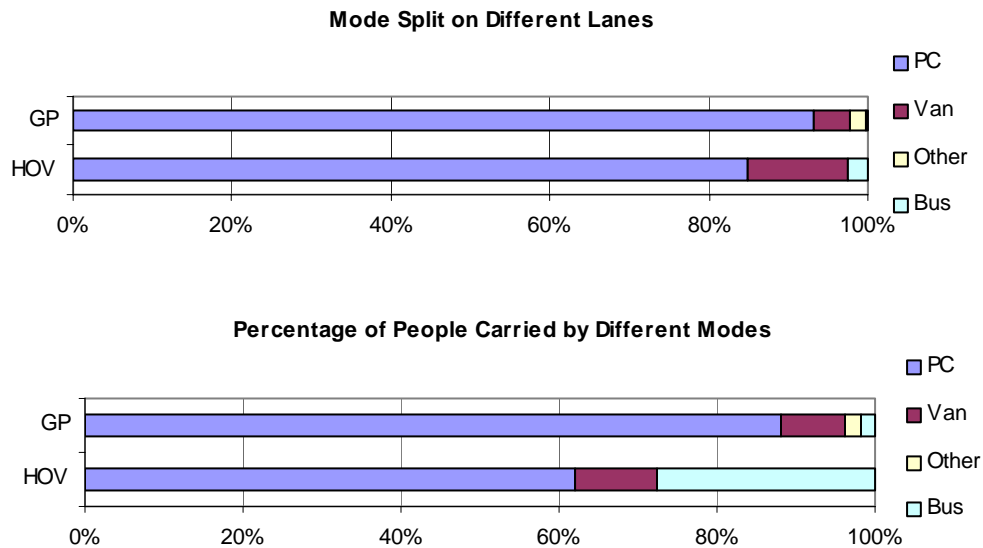


Figure 4.2-1 Passengers by mode and lane type

4.3 GP Lanes vs. HOV Lanes Throughput

Throughput refers to roadway person-movement and/or vehicle-movement on HOV and GP lanes. It is necessary to analyze both person and vehicle throughput in order to evaluate an HOV lane. Three representative I-15 sites located at 2700 South, 3900 South, and 5800 South were selected for detailed manual analysis. Selection was based on points of interest, availability and usability of manually collected data as well as the TMS data.

Based on Figures 4.3-1 through 4.3-2, several pieces of throughput information are depicted for each representative site. The vehicle and person throughput data for GP and HOV lanes are also presented as both overall and per-lane statistics. This information is shown as Figure 4.3-3. This identifies the proportion of total throughput the HOV facility provides, while also allowing an

impartial comparison of how much throughput the HOV lane is providing in comparison to the average GP lane. The Average Vehicle Occupancy (AVO) rate is also presented.

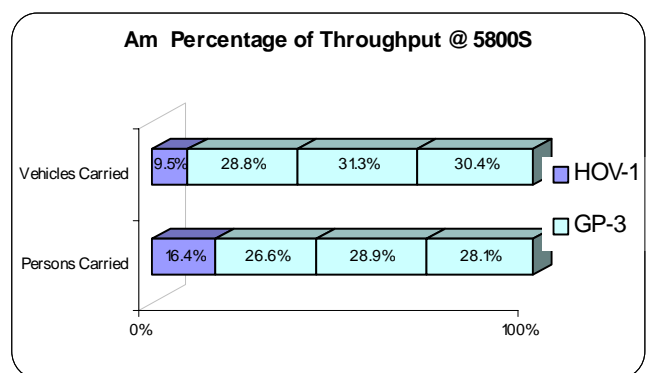
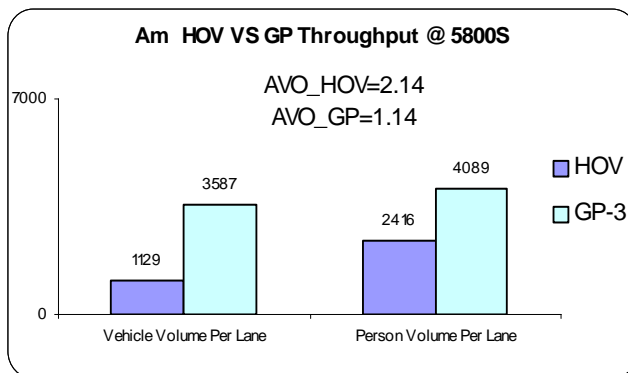
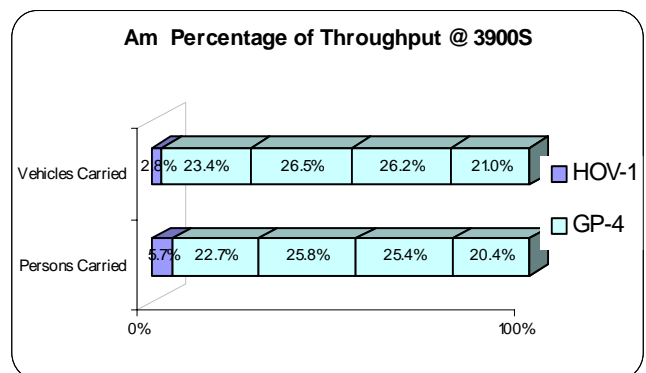
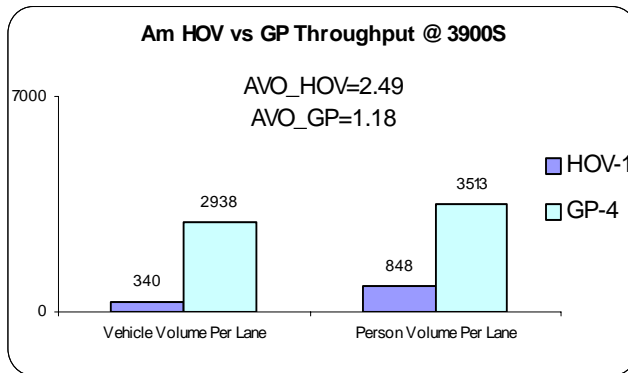
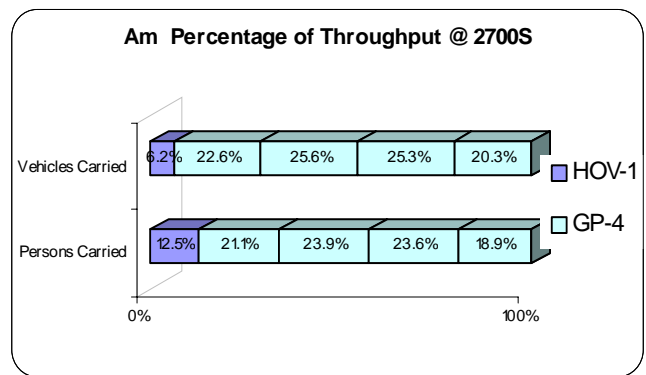
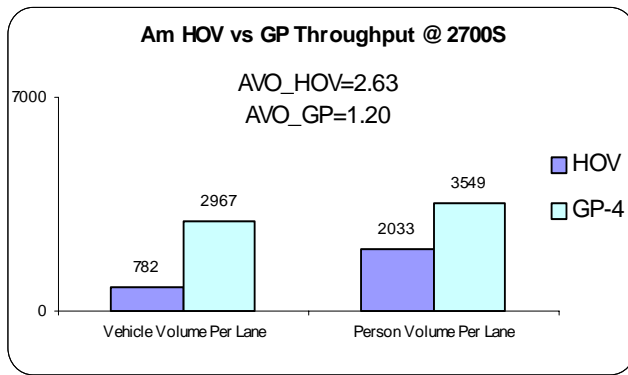


Figure 4.3-1 Throughput Comparisons at Different Locations During Morning Peak Period

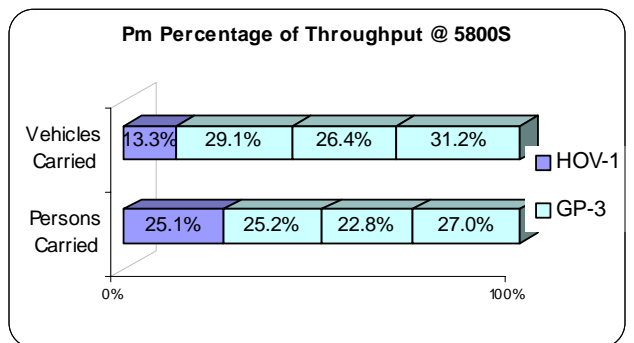
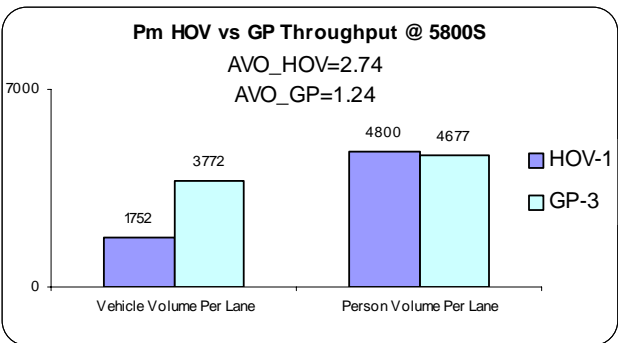
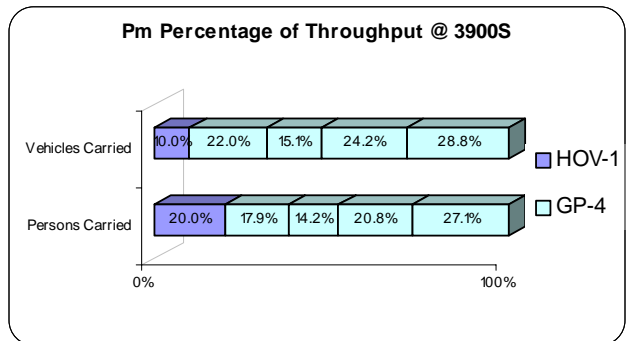
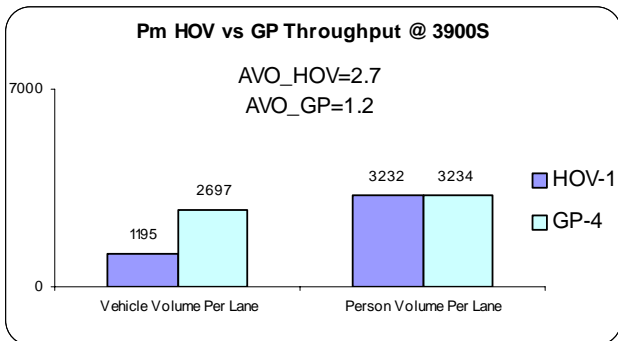
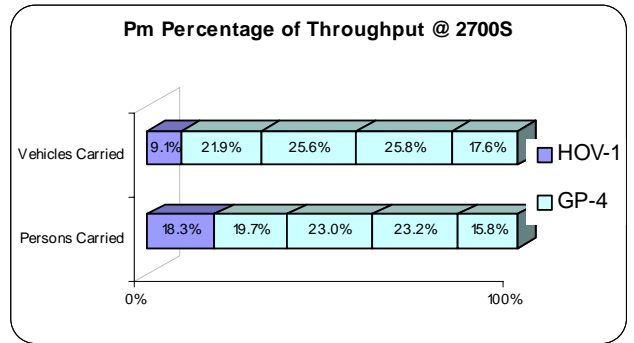
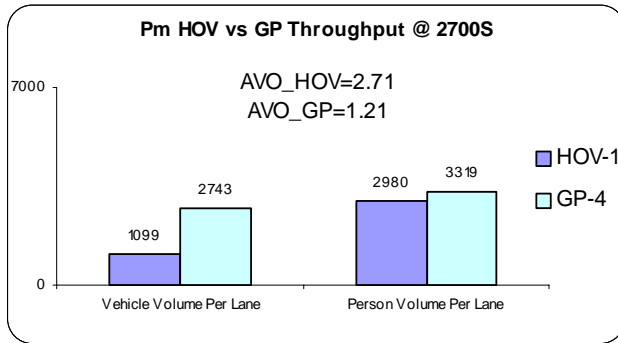


Figure 4-3-2 Throughput Comparisons at Different Locations During Afternoon Peak Period

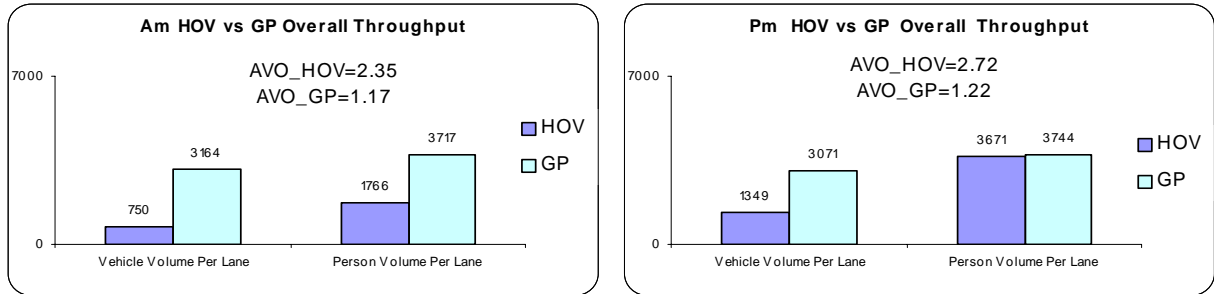


Figure 4.3-3 Overall Throughput Comparisons During Peak Periods

According to the Figure 4.3-3 data, on a per-lane analysis, the Northbound HOV lane carried 1766 persons during a two-hour period in the AM peak period. Compared with the GP lanes, the HOV lane carried 52.2% fewer people and 76.3% fewer vehicles. During the two hour PM peak period, the Southbound HOV lane carried almost the same number of people as a GP lane, but with 56.2% fewer vehicles. As anticipated, it can be concluded that the HOV lane displays its value during the more congested periods.

4.4 HOV Lanes' Usage during the 2002 Winter Olympic Games

The 2002 Salt Lake City Winter Games were the largest Winter Olympic Games ever held. They included 78 events in 15 disciplines and seven sports. Over 1.5 million tickets were sold for the Olympic events and over 500,000 visitors attended the Games. These numbers created unprecedented travel needs. The I-15 corridor with HOV lanes played an important role for the Olympic Games providing the majority of freeway capacity in the Salt Lake Valley.

More than one month's worth of continuous traffic monitoring, before, during, and after the Olympic Games, was conducted (14). The HOV lanes' usage was analyzed based on a comparison between traffic during and after the Olympic Games. The 24-hour overall transportation demand during the Games was only 15% higher than after the Games. This is attributed to most people in the Salt Lake area operating with either a working break, a modified schedule, or increased rideshare efforts during the Olympic Games. This shows a great effort on

the part of engineers, planners, and Olympic coordinators to inform the public of the coming traffic and therefore the need to reduce typical commuter demand during the two-week Olympic period. These preparations were estimated to reduce the background traffic along I-15 by up to 40%. Table 4.4-1 shows a sample location showing that 24-hour traffic volumes on the HOV lanes during the Olympics were 16 to 18% higher than after the Olympics w the GP lanes increased only by 3 to 4%. One reason for this increase is travel behavior changes. More local travelers carpooled, less commuter traffic was on the road due to work schedule shifts, and visitors tended to be multi-rider vehicles. The time saving advantages of the HOV lanes enticed carpoolers to utilize them. Many of the events were held in the downtown area at night. This resulted in another peak period on the HOV lanes. This one occurred from 9:00 to 11:00 P.M., as shown in Figure 4.4-1. Therefore, the HOV facilities, like the efficient public transportation systems including the Light Rail TRAX, Olympic bus, regular bus, contributed to lessen congestion on the transportation systems during the Olympic Games.

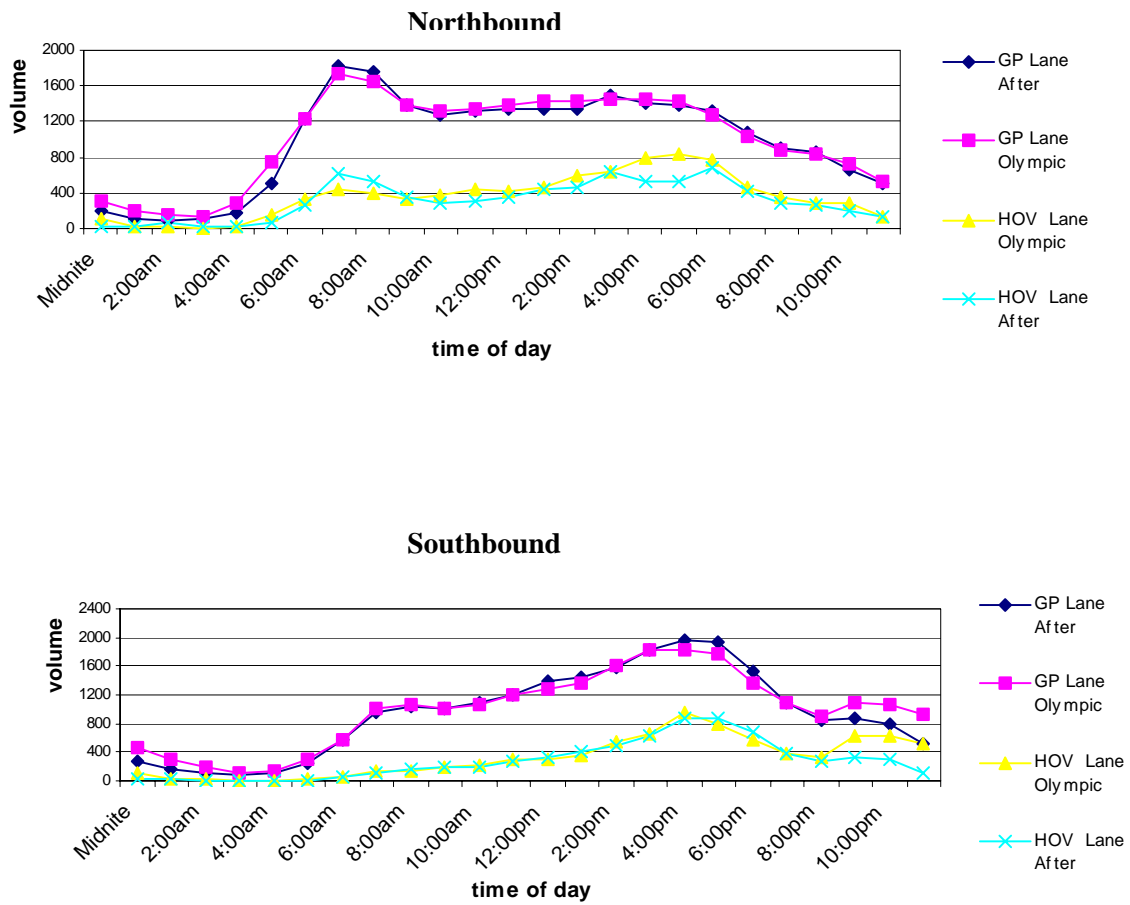


Figure 4.4-1 Traffic Volume Comparison During Olympic Games

Table 4.4-1 24-hour Traffic Volume Changes at I-15 5800S between during and after Olympic Games

	Northbound			Southbound		
	After Olympic	During Olympics	Volume Change	After Olympic	During Olympics	Volume Change
GP Lane	23659	24399	3.1%	22617	23523	4.0%
HOV Lane	7473	8709	16.5%	6666	7907	18.6%

traffic volume unit: vehicles/per lane/per day

CHAPTER 5. TRIP RELIABILITY AND TRAVEL TIME SAVINGS

One of the best gauges as to whether HOV facilities are offering a benefit is travel speed and reliability. In Los Angeles, increased travel time is a secondary consideration to users and the reliability of the trip time is more important. As congestion increases in the Salt Lake Valley, commuter reliability will become much more of a consideration in selecting routes and mode choice. The corridor-wide and site-specific operational performance of HOV facilities are presented in this section, and some terms, such as speed, reliability, congestion pattern, travel time, to describe the operational performance of HOV are measured. The purpose of these measures is to describe the following:

- HOV lane travel speeds that can be expected for a range of trip start times throughout the day
- likelihood of the average trip in the HOV lane becoming congested (with a speed of less than 45 mph)
- how traffic conditions change from location to location along an HOV lane and GP lane in different traffic periods
- the travel time savings realized when the HOV lane is used

5.1 Corridor-wide Operational Performance

This section describes the performance measures used to evaluate the operational characteristics of the entire HOV system along I-15. The operational performance is discussed independently, in regard to different direction and different peak periods. The operational performance was assessed with the following measures: speed, trip reliability, and travel time savings. Each measure is defined below.

5.1.1 Travel Speed

The HOV lane performance should reflect higher average speeds than the GP lanes during peak times. Table 5.1-1 assesses the average weekday HOV and GP lane location speed along I-15 from 400S to 10600S. The statistical results show that the vehicle speed on the HOV lanes was always higher than the speed of GP lanes throughout the day. During the afternoon peak period, the average speed on the HOV lane was 63.6 miles per hour (MPH), which was significantly greater than the 51.5 MPH on the GP lanes.

During travel time runs along I-15, speeds less than 45 MPH are considered congested. In the AM peak period and off peak period, speeds along the corridor are above 45 MPH. During the PM peak period, 31% of the I-15 corridor operates at or below 45 MPH in the GP lanes. Only 10% of the HOV lane operates at or below 45 MPH in the PM peak. Table 5.1-1 displays the speed data collected on the multiple travel time runs.

Table 5.1-1 Average Weekday HOV and GP Lane Location Speed

	Morning Peak (Northbound)		Afternoon Peak (Southbound)		Off Peak	
	HOV	GP	HOV	GP	HOV	GP
Mean	74.0	65.7	63.6	51.5	74.2	68.4
Standard Deviation	3.3	4.0	10.8	16.7	2.6	3.8
Percentage < 45 MPH	0	0	10.3%	31.0%	0	0

5.1.2 Trip Reliability

Trip reliability is a measure of the expected range in travel time and provides a quantitative measure of its predictability. Reliability of travel time is a substantial benefit to travelers, as they

are able to predict their travel times better and can therefore budget less time for their trips.

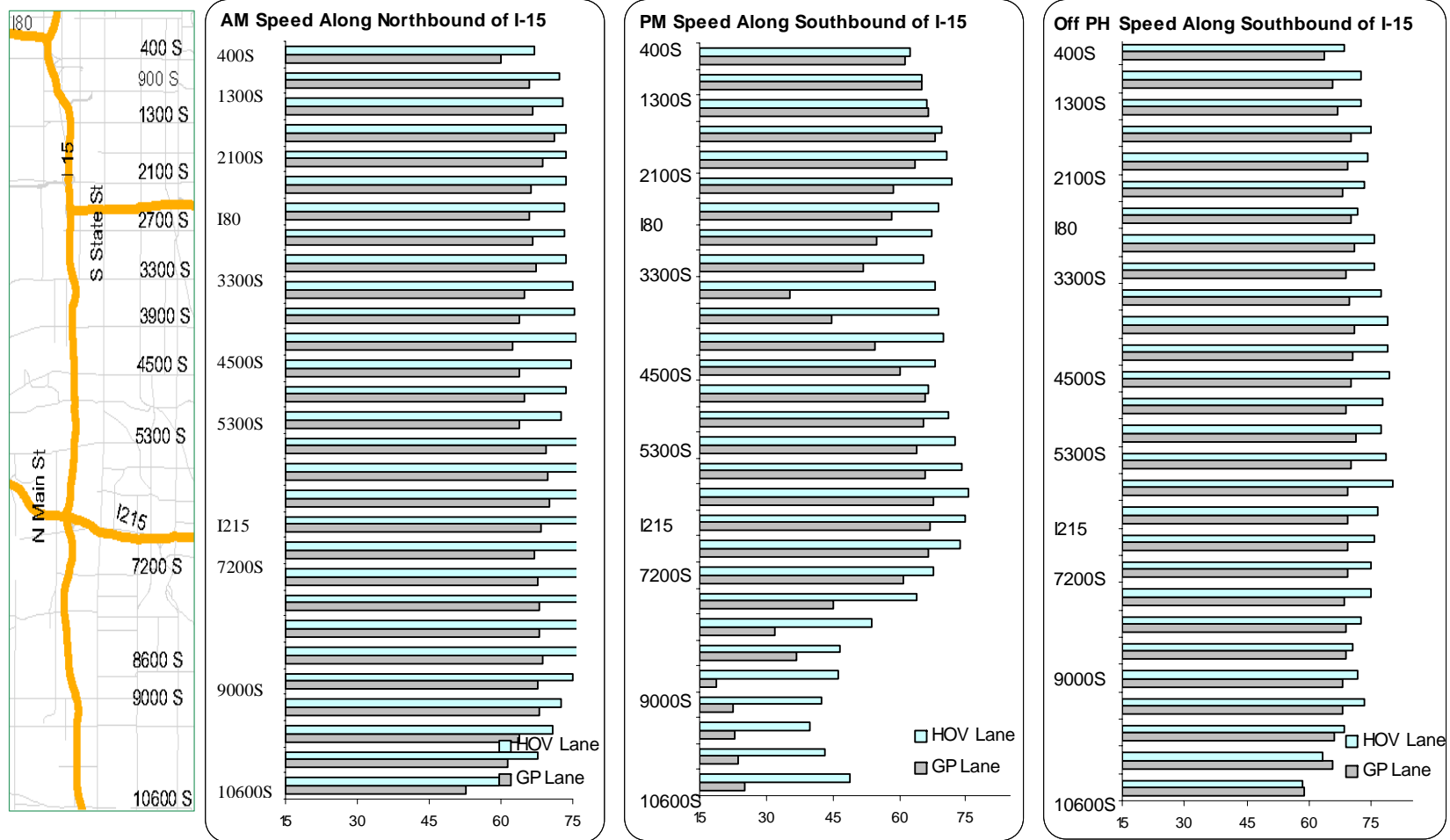
Travel time saving is another measure of corridor-wide HOV performance. It allows individual travelers to compare their own experiences against the reported statistics. It is also useful for tracking changes in facility performance over time and for comparing the GP and HOV lane performance. Travel times are estimated for a range of start times for trips that traverse the length of the particular GP and HOV lane from 400S to 10600S. Table 5.1-2 quantifies changes in travel time on average weekdays. For all of the runs during the congested PM peak period, the travel-time difference on the HOV lane was 3.9 minutes, less than on the GP lane. During the off peak period and AM peak period with low congestion level, the difference of travel time on both the HOV and GP lane was small. It should be noted that all the travel time runs occurred on days where there were no incidents on I-15. Qualitative observations show that the HOV benefit increases dramatically when an incident causes above normal congestion on the GP lanes.

Table 5.1-2 Average Weekday HOV and GP Lane Travel Time Comparison

	Average Travel Time (min)		Time Savings (min)	Percentage HOV Time Savings
	HOV	GP		
AM Peak	11.3	13.1	1.8	13.4%
Off Peak	11.5	12.1	0.6	4.7%
PM Peak	14.7	21.2	6.5	30.7%

Note: travel time unit is minute

Figure 5.1-1 illustrates the variation of travel speeds along I-15 on the HOV and GP lane during the AM, PM and off- peak period, respectively. The conclusion is that little advantage is available from HOV usage in the AM and off-peak times but the trips using the HOV lane can keep stable speeds and more predicable travel time during the PM peak relative to the GP lane.



Note: Speed Unit is MPH

Figure 5.1-1 Variation Of Speed Along The HOV And GP Lane In Different Periods

On average, the HOV lane users experience a travel time advantage of nearly 7 minutes during the PM peak period over the adjacent GP lane travelers. During the morning peak period with low level of congestion, the HOV lane does show a users benefit of 13.4% in travel-time savings. In contrast, during the off peak period, the travel times along the HOV and GP lanes are almost the same.

HOV lane travel-time savings is due to a variety of causes. This includes low levels of traffic congestion on the HOV lane during the AM and off-peak commute. From the speed analysis, the vehicles traveling on the HOV lane always maintain high and stable speed. In contrast, the GP lane vehicle speeds vary due to congestion, whether due to recurring traffic demand or non-recurring incidents.

One interesting point that should be made is that often the HOV lanes do not operate at expected speeds relative to the volume. For example, the speeds of an HOV lane, adjacent to a congested GP lane, are often less than the speed limit even though the flow is well below capacity. This is often a sympathy speed. To an HOV driver, the disparity in speed between their vehicle and the adjacent GP congested lane speed is uncomfortable and therefore HOV lane travel slower. This can be thought of as a continuous incident. Typically a disabled vehicle on the shoulder causes the speed of the adjacent lane to slow at the point of the disabled vehicle. The congested GP lane acts a continuous line of “disabled” vehicles, which slows the HOV lane travel speeds, the more positive separation available between the HOV lanes and GP lanes, the lower the impact of sympathy speeds. In southern California, a 4-foot striped median is incorporated to provide more positive separation between the HOV and GP lane. On some freeways, a physical separator, such as jersey barriers or pylons, limits entry and exit points to the HOV lanes but further reduces the impact of sympathy speeds.

5.2 Site-Specific Operational Performance

The corridor-wide measure provides a top-level overview of system performance. Examining the operation of HOV lanes at specific locations can show more details about HOV lane performance. Figure 5-2-1 illustrates the average travel speed in 15-minute intervals on each lane throughout one 24 hours weekday at a sample location.

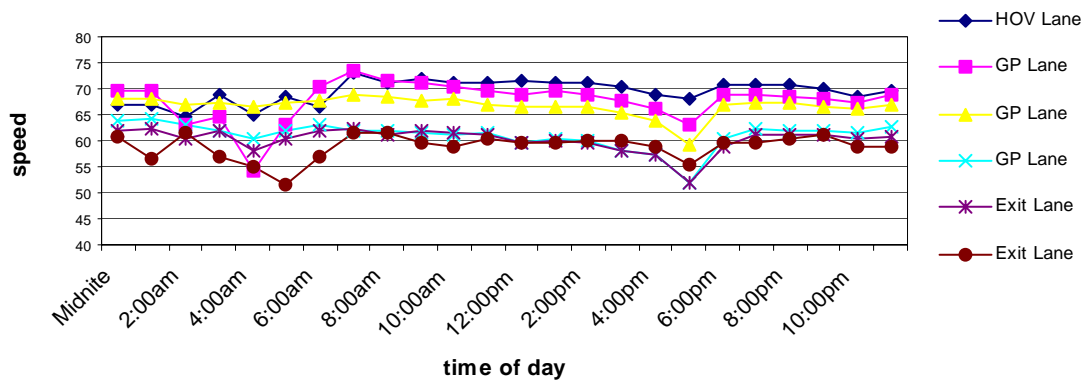


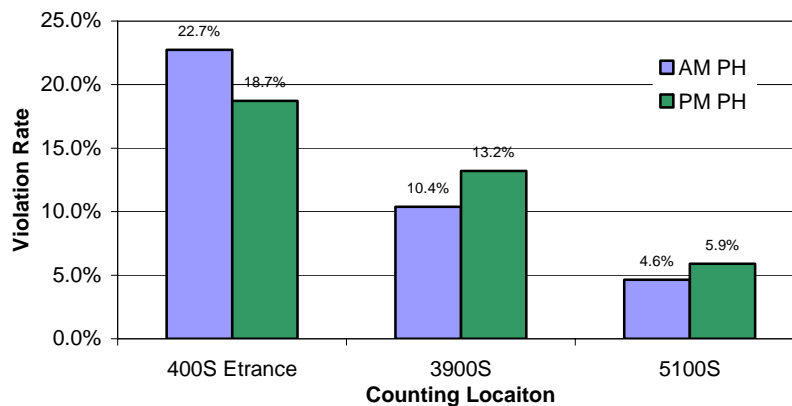
Figure 5.2-1 24-hour Traffic Speed Profile at 5800S Southbound

CHAPTER 6. VIOLATIONS

Measuring violations identifies the acceptance of the system. High violation rates negates from the HOV lane effectiveness. A violation evaluation at different locations and during different operating times is provided based upon the field data collected within the peak periods.

HOV violation rates are not constant and vary from location to location along a facility. Figure 6-1-1 represents the average violation rate at representative locations along I-15.

Figure 6.1-1 Violation Comparison by Location



In general, the higher the congestion level, the higher the violation rate as the single-occupancy vehicles are more willing to take advantage of the HOV lane because of a higher perceived risk-benefit. In addition, violation rates tend to increase near points where HOV lanes merge with general purpose lanes and HOV ramps, as some motorists seem to believe that getting into the HOV lane “just a little early” is not really a violation, and the short time spent in the HOV lane limits the chance that they will be observed by a highway patrol officer. For example, the violation rates at HOV lane’s 400S entrance is above 20 percent. Violation rates vary depending on the level and method of enforcement, but are typically around 10 percent according to national experience and enforcement. Concurrent flow HOV lanes typically have higher violation rates, especially at HOV ramps. The results of a more detailed investigation at the 400 South HOV

ramp includes monthly violation counts throughout the year as well as one-week of continuous peak hour monitoring. The results from the continuous week of observations are shown in Table 6.1-1 by direction.

Table 6.1-1 Violation Rates at HOV Lane's Ramp during Weekday

Day of Week	On ramp				Off ramp			
	From East to SB I-15		From West to SB I-15		From NB I-15 to East		From NB I-15 to West	
	AM	PM	AM	PM	AM	PM	AM	PM
Monday	17.6%	16.4%	15.0%	21.3%	1.1%	7.3%	20.5%	16.8%
Tuesday	22.8%	21.3%	18.6%	21.0%	2.9%	7.4%	23.6%	15.3%
Wednesday	21.7%	18.5%	17.0%	20.0%	1.6%	4.9%	27.2%	19.0%
Thursday	29.7%	17.6%	30.1%	16.9%	2.8%	5.6%	27.0%	15.1%
Friday	26.9%	18.9%	24.3%	17.6%	3.4%	3.9%	27.7%	14.9%
Average	23.7%	18.5%	21.0%	19.4%	2.3%	5.8%	25.2%	16.2%

The higher HOV ramp violations resulted in the ramp being monitored closely throughout the initial year of operation to determine how enforcement and education influenced the violations. Figure 6.1-2 shows how the violation rate changes during the initial year of HOV operations. The most dramatic change in violation rates occurred during the early stages of operation. This was indicative of the early enforcement and education. The violation rate was approximately 50% in the first month of HOV operation. Generally, the number of violations has decreased steadily from 24% on July 2001 to 18.7% one year later. This decrease is in part fueled by the increased use of the HOV lane system, and also by highway patrol enforcement. However, the 18.7% violation is still high for a facility of this nature.

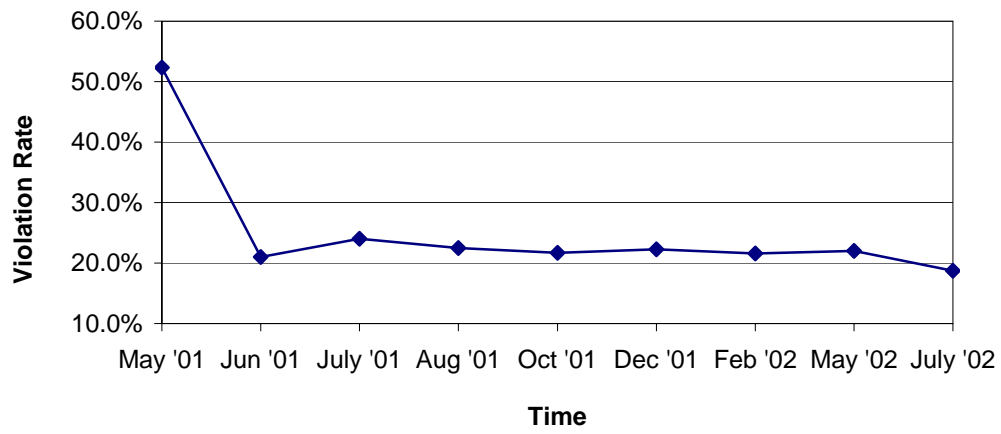


Figure 6.1-2 Violation Rates At 400 South HOV Ramp

CHAPTER 7. AVERAGE VEHICLE OCCUPANCY

Successful HOV lanes must not simply divert existing HOVs from GP lanes to the HOV lane, but must also generate new HOV, resulting in increased AVO. According to the nationwide statistics, as auto ownership has increased, average vehicle occupancy (AVO) from home to work trips has declined from 1.3 in 1977 to about 1.14 in 1995 (3). With the reconstruction of I-15, the increase in capacity may actually promote a decrease in occupancy by increasing available travel opportunities. Figure 7.1-1 illustrates AVO changes during peak periods before and after HOV lane operation. In order to provide a comprehensive evaluation of freeway operations throughout the Salt Lake Valley, other freeways without HOV lanes were surveyed during the same survey periods. Some of these non-HOV selected locations include: I-15 and 600N of, I-215W and 3100S, I-215E and 4500S.

At the locations without HOV facilities, the AVO remained constant. In contrast, on the I-15 corridors with HOV lanes, AVO had a significant increase of 20%, increasing from 1.1 to 1.3. The meaningful increase in AVO contrasted to a national decline of AVO, supports the HOV lane implementation has increased transit and ridesharing.

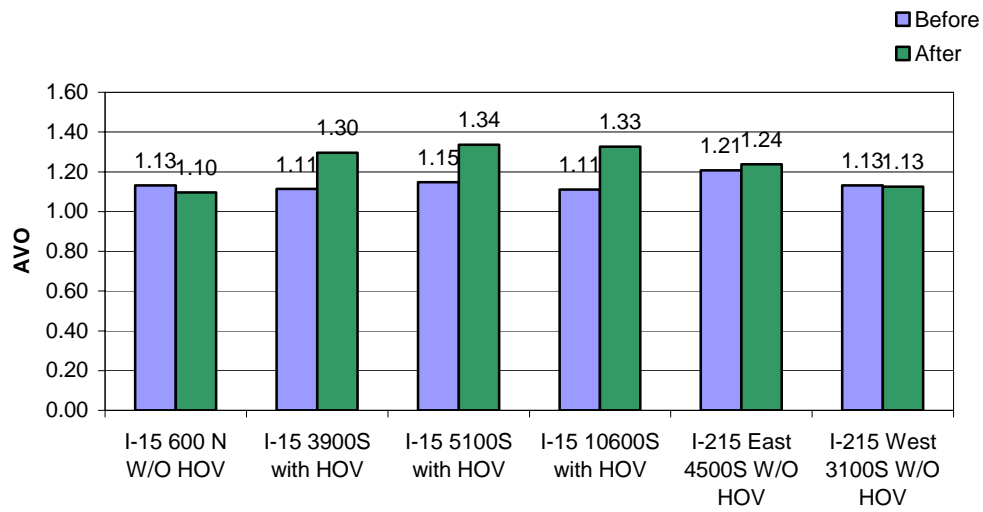


Figure 7.1-1 Change of AVO before and after HOV operations

CHAPTER 8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The analysis and results are based on the comprehensive evaluation of the first year of operation of HOV lanes on the I-15. Based on the per lane analysis, HOV lanes almost carried the same volume of people as the GP lanes did and 44 percent of vehicles carried by the GP lanes during the PM peak time. During the rest of the day with no congestion, HOV lanes moved less people per lane than its GP lane counterparts. However, this is not uncommon as the freeway is much less congested during the other times relative to the PM peak. Judging from the person throughput of HOV lanes, the HOV facility approaches its minimum pre-construction goal, which is to be able to move at least as many people as a GP lane does during the peak periods.

The travel time savings and reliability available to HOV commuters include faster travel along their entire length during peak periods and directions. The statistical result shows that the vehicle speed in HOV lane was always higher than in GP lanes throughout the day. Based on the average weekday analysis, during the afternoon peak period in southbound, the average speed in HOV lane was 63.6 mph, which was substantially greater than the 51.5 mph in GP lanes. During the morning peak period in northbound, the average speed in HOV lane was 74.0 mph, and was higher than 65.7 mph in GP lanes. Due to the difference of travel speed between HOV lanes and GP lanes, the travel time along the whole length of HOV lane during afternoon peak period had 6.5 minutes' benefit compared to that of GP lanes. The HOV corridor PM peak timesavings is 30.7 percent compared to the time spent in GP lanes while the morning peak period and off peak period time savings are 13.4 percent and 4.7 percent respectively.

HOV violation rates vary in different time of operation, and also in different locations of the HOV lanes. During the peak periods, the average violation rates was 20 percent at the 400 South

HOV on/off ramp, which is substantially higher than the violation on segment of I-15 which range from 5 percent to 13 percent. Generally, the violation rates in afternoon peak period, with higher levels of congestion, are higher than the morning peak period.

Public acceptance regarding HOV lanes is concluded from advantages of HOV lanes that induce people to shift from single-occupancy-vehicle use to transit or HOV. After one year's operation of HOV lanes in the I-15 corridors, AVO had a 17 percent increase from 1.1 to 1.3. AVO on other Salt Lake Valley freeway segments without HOV lanes remained the same during the analysis period. Therefore Implementation of the HOV lanes has obtained the public support and increased the volume of carpools.

8.2 Considerations / Recommendations

The findings indicate a successful HOV system, particularly when consideration is given to the newly constructed I-15 with spare capacity. Relative to other urban areas where HOV lanes have been installed, Salt Lake City has relatively low congestion and therefore lower need for HOV facilities. As the congestion increases, the benefits of the HOV lanes should also increase.

Continued monitoring is the best way to identify and track these increasing benefits.

As shown in the Figure 4.1 and Figure 4.2-1, it is apparent that the HOV lanes are currently underutilized. In contrast, traffic volumes in the GP lanes always keep the relative higher level between the morning peak time and afternoon peak time. Therefore, in the short term, changing the operating policy to open HOV lanes to all traffic during off peak time would more efficiently move traffic flow. However, in the long term, as congestion during off-peak times increases, then the advantages to the HOV users would be eliminated and so monitoring of the system is key to adjusting policy as congestion demands.

According to the violation rates analysis, violations are higher than national averages, particularly at the 400 South ramps. Although the lack of barrier separation makes it difficult to enforce more complicated strategies to violators, such action such as utilizing various media to educate people to obey the HOV lanes' restriction, more rigorous enforcement to target violators and a program of other drivers reporting HOV violators, such as Seattle's HERO program could be considered.

Compared with the HOV lanes' performance in other state, the HOV lanes in the I-15 just use their potential partially. Additional marketing of the program may be helpful in increasing usage, particularly if the potential travel timesavings were more widely known. More personal interviews and focus groups with HOV users and Non-HOV users would be helpful to examine why demands has not been higher and to elicit why participants do not seem to be using the service more frequently. The most obvious reason is that the newly reconstructed I-15 simply does not have sufficient congestion to encourage large-scale use of HOV. As the congestion increases, the usage should also. This is why a continued monitoring effort should be made to track the HOV operations.

Some state, such as such as Minnesota and California conduct the continuous HOV lanes monitoring from the beginning of operation. Also, annual evaluation reports provide performance measures of HOV lanes. New policies are recommended to improve the efficiency of HOV lanes each year. We suggest UDOT should improve its HOV data collection efforts, conduct periodic statewide surveys to determine the impact of HOV lanes on carpooling, and report on and develop a statewide plan to promote lanes' usage. The report should include the automated information available from the TMSs as well as vehicle occupancy and violation rate measures. The measures set forth in this study should be the data collected. These include:

1. Average Vehicle Occupancy on HOV and GP lanes for I-15 and other freeways.
(Manual collection process)
2. Volume for HOV and GP lanes
3. Travel time and reliability for the corridor by HOV and GP lanes. This can be acquired manually or implied from the TMS speed information.
4. Violation rates. While research in California is working on automated methods for determining vehicle occupancy, this is still primarily a manual process.

This data will support HOV lane performance assessments as reported in this study. With no national guidelines on the evaluation of a HOV facility, it is important that the DOT's take it upon themselves to monitor the facilities so when/if public discontent occurs, as experienced in New Jersey, then data is available to document the advantages of the HOV lane and discourage the "empty syndrome" argument.

Statewide TMS is an important source of traffic data collection. During the process of data collection, we found that only 70 percent of TMS can provide valid data in UDOT's more than five hundred's stations. Only 50 percent of TMSs covering the HOV lanes from 600N to 10600S along I-15 corridor provided complete data, even fewer provide both reliable traffic speed data and volume data. For the continuous monitoring of HOV lanes, frequent maintenance of TMS is strongly recommended.

From Figure 5.1-1, the travel speed in both HOV lanes and GP lanes drop from the 7200S to 10600S for I-15 Southbound during the PM peak period. This is not surprising since three separate directions of freeway converge at the I-215 / I-15 interchange. The high volume results in recurring congestion in both HOV lanes and GP lanes. Along that segment, with only 25 percent of entire road length, more than 35 percent of travel time was spent.

Much of the PM peak period congestions is caused by spillback from congestion at 10600S where not only the HOV lane merge into GP lanes, but also one GP lane is subtracted. A significant queuing in this segment occurs because of this road bottleneck. The primary value of the HOV lane comes from queue jumping. Making geometrical improvements, such as providing on/off ramp for HOV at the 10600S exit or extension of HOV lanes after this point would greatly improve the travel time saving benefit of HOV lanes. Overall improvements to the widening of I-15 south from 10600 South is likely to result in reduced HOV benefits during the PM peak as the congestion diminishes.

Consideration should be given to inside ramps for the HOV lanes as HOV users in the PM peak must cross four congested GP lanes to exit the freeway and therefore many potential users do not use the HOV facility for short freeway trips or once in the more congested southern portion of the freeway. As the I-15 South widening occurs in the future, inside HOV ramps at 11400 South, 12600 South, Bangerter Highway and 14400 South should be considered. Atlanta, Seattle and LA have all incorporated direct HOV ramps for freeway-to-freeway connectors and arterial connections resulting in increased utilization.

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APPENDIX

I 15 Northbound 24-Hour Traffic Volume Profiles at 5800 South during a Weekday

Detector Location	Mid	AM											PM											
	Night	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
HOV Lane	32	17	65	18	32	67	256	611	518	343	280	315	357	432	463	635	531	534	683	420	289	265	189	121
Exit Lane	46	36	16	14	30	90	338	653	799	594	546	540	596	630	588	705	722	735	522	394	323	316	239	142
GP Lane	185	122	100	100	170	456	1111	1728	1700	1382	1285	1386	1349	1380	1425	1521	1446	1371	1282	1067	889	873	667	511
GP Lane	214	139	106	134	198	578	1295	1912	1812	1459	1325	1339	1406	1376	1394	1537	1432	1413	1372	1115	966	907	696	563
GP Lane	169	88	66	81	150	497	1296	1850	1774	1311	1196	1253	1275	1255	1206	1453	1356	1357	1314	1081	856	808	625	465
Exit Lane	33	21	14	15	31	202	993	1930	1641	1017	806	808	865	887	948	1195	1056	1108	1048	725	481	456	313	170

I 15 Southbound 24-Hour Traffic Volume Profiles at 5800 South during a Weekday

Detector Location	Mid	AM											PM											
	Night	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
HOV Lane	22	15	2	3	4	13	43	117	151	179	190	266	331	411	482	632	873	879	670	377	264	323	304	115
GP Lane	127	47	26	18	26	77	281	635	759	704	796	924	1119	1207	1343	1726	1964	1950	1362	873	571	639	567	281
GP Lane	289	185	111	61	106	290	650	999	1100	1060	1159	1254	1365	1405	1540	1676	1789	1751	1457	1116	847	917	769	533
GP Lane	385	280	189	148	195	349	760	1227	1287	1250	1340	1458	1697	1760	1830	2042	2125	2100	1763	1309	1089	1101	1013	704
Exit Lane	190	123	82	58	62	145	291	681	841	826	827	1043	1227	1231	1302	1461	1651	1758	1345	894	716	675	642	402
Exit Lane	62	27	31	22	17	40	61	221	255	249	300	337	439	426	416	513	539	680	427	270	211	227	182	136

Unit: Vehicles Per Hour

I 15 Northbound 24-Hour Traffic Volume Profiles at 5800 South during the Olympic

Detector Location	Mid	<i>AM</i>											<i>PM</i>											
	Night	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
HOV Lane	115	29	14	4	31	163	335	443	403	326	364	448	408	469	601	636	784	837	761	468	359	291	281	139
Exit Lane	91	50	43	22	58	128	364	720	820	567	521	600	607	624	656	691	696	621	515	377	323	265	215	185
GP Lane	265	193	139	112	251	605	1092	1687	1667	1458	1347	1412	1488	1477	1438	1464	1459	1399	1235	987	858	791	651	487
GP Lane	367	221	178	164	319	836	1310	1806	1674	1387	1333	1367	1410	1471	1497	1508	1446	1500	1314	1132	926	904	786	605
GP Lane	316	162	125	112	263	786	1312	1742	1624	1334	1252	1271	1274	1334	1379	1398	1421	1415	1267	1002	877	838	751	518
Exit Lane	143	34	29	24	69	426	1065	1592	1323	1004	818	868	893	954	1031	1158	1228	1243	1070	710	530	489	428	239

I 15 Southbound 24-Hour Traffic Volume Profiles at 5800 South during the Olympic

Detector Location	Mid	AM											PM											
	Night	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
HOV Lane	113	33	20	7	6	18	56	146	140	179	210	293	311	361	545	655	954	799	575	385	334	621	637	509
Exit Lane	304	138	68	38	46	133	338	695	704	665	728	939	1035	1078	1425	1726	1767	1673	1206	878	687	922	882	796
GP Lane	497	299	199	130	151	327	644	1098	1075	1077	1112	1195	1293	1336	1476	1734	1623	1628	1311	1100	910	1093	1080	939
GP Lane	595	427	301	182	230	437	746	1241	1380	1306	1326	1470	1524	1684	1923	2023	2051	2019	1594	1314	1100	1242	1201	1056
GP Lane	305	228	152	87	98	160	320	671	940	842	837	1096	1175	1263	1437	1504	1587	1670	1178	848	691	764	696	616
Exit Lane	66	76	41	20	21	40	85	193	262	260	259	318	386	438	472	536	552	571	350	292	230	221	212	169

Unit: Vehicles Per Hour

24-hour Traffic Speed Profile at 5800S Southbound during a Weekday

Detector Location	Mid	AM											PM											
	Night	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
HOV Lane	67	67	64.5	69	65	68.3	66.5	73	71.3	71.8	71.3	71.3	71.5	71	71.3	70.5	69	68	70.8	70.8	70.8	70	68.5	69.5
Exit Lane	69.5	69.5	63.3	64.8	54.3	63.3	70.3	73.5	71.5	71	70.3	69.8	69	69.5	68.8	67.8	66.3	63	68.8	69	68.5	68.3	67.5	68.75
GP Lane	68.25	68.3	67	67.3	66.5	67.3	67.8	68.8	68.5	67.8	68	66.8	66.5	66.5	66.5	65.5	63.8	59.3	66.8	67.3	67.3	66.5	66.3	67
GP Lane	63.75	64.3	63	62	60.3	61.8	63	62	61.8	61.5	61.3	61.5	59.8	60.5	60	58.3	57.3	51.8	60.5	62.3	62	61.8	61.5	62.75
GP Lane	62	62.3	60.5	61.8	58.3	60.3	61.8	62.3	61.3	62	61.5	61	59.5	60	59.5	58	57.3	52	58.8	61	61.3	61	60.5	60.75
Exit Lane	60.75	56.5	61.5	56.8	55	51.5	56.8	61.5	61.5	59.8	58.8	60.5	59.8	59.8	60	60	59	55.3	59.5	59.8	60.5	61	59	59

Unit: Miles Per Hour

Variation Of Speed Along The HOV And GP Lane In Different Periods

Intersection	PM Peak Southbound		AM Peak Northbound		Off Peak Time	
Location	GP	HOV	GP	HOV	GP	HOV
10600S	25	49	53	60	59	58
	24	43	61	68	66	63
	23	40	64	71	66	68
	23	43	68	73	68	73
	19	46	68	75	68	72
9000S	37	47	69	78	69	71
	32	54	68	78	69	73
	45	64	68	78	69	75
8600S	61	68	68	78	69	75
	67	74	67	78	69	76
	67	75	69	78	70	77
7200S	68	76	70	79	69	80
	66	74	70	78	70	79
I215	64	73	70	76	71	77
	65	71	64	73	69	78
5300S	66	67	65	74	70	79
	60	68	64	75	71	79
4500S	55	70	63	76	71	79
	45	69	64	75	70	77
3900S	35	68	65	75	69	76
3300S	52	66	67	74	71	76
	55	67	67	73	70	72
I80	58	69	66	73	68	73
2100S	59	72	66	74	69	74
	64	71	69	74	70	75
1300S	68	70	71	74	67	73
	67	66	67	73	66	73
600S	65	65	66	72	65	68
400S	61	63	60	67	64	65

Unit: Miles Per Hour